VIBRATING SYSTEM AND METHOD FOR USE IN SCALE REMOVAL AND FORMATION STIMULATION IN OIL AND GAS RECOVERY OPERATIONS

Background

[0001] This invention relates to a vibrating device for use in scale removal and formation stimulation in an oil and gas recovery operation.

[0002] In many oil and gas downhole recovery operations, scale, or salt crystal growths, and other foreign materials (collectively referred to as "scale") are often precipitated during production of the reservoir fluids which can compromise the fluid recovery. For example, in high-rate, high-permeability completions, reservoir fluids are recovered that contain fines, or formation sand. Therefore, support and screening devices, such as screens, slotted liners, and the like, have been utilized to support a gravel pack, or the like, in the well to stabilize the formation while permitting the recovered fluids to pass from the formation into the wellbore while preventing passage of fines or formation sand with the recovered fluids.

[0003] However, scale often accumulates on the devices and must be removed either mechanically, which adds to the labor and cost of the project, or chemically, which may harm the metal parts of the devices and/or cause the dissolved scale to flow into the formation and thus potentially compromise the productivity of the well.

[0004] Also, during the recovery operation from the wellbore, a "skin" develops around the wall of the wellbore which impedes the flow of fluid from the formation requiring stimulation techniques to remove the skin and stimulate the formation.

[0005] Therefore, what is needed is a device of the above type that simultaneously performs the above scale removal and stimulation of the well, yet eliminates the above problems.

Brief Description of the Drawings

[0006] Fig. 1 is a part diagrammatic, part sectional, and part elevational view of an embodiment of the sand control system of the present invention shown in a downhole environment.

[0007] Fig. 2 is enlarged view of a portion of the system of Fig. 1.

Detailed Description

[0008] Referring to Fig. 1, the reference numeral 10 refers to a wellbore penetrating a subterranean ground formation F for the purpose of recovering hydrocarbon fluids from the formation. To this end, and for the purpose of carrying out specific operations to be described, a tool 12 is lowered into the wellbore 10 to a predetermined depth by a work string 14, in the form of wire line, coiled tubing, or the like, which is connected to the upper end of the tool 12 in a manner to be described. The tool 12 is shown generally in Fig. 1 but will be described in detail later.

[0009] The string 14 extends from a rig 16 that is located above ground and over the wellbore 10. The rig 16 is conventional and, as such, includes, inter alia, support structure, a motor driven winch, and other associated equipment for receiving and supporting the tool 12 and lowering it to a predetermined depth in the wellbore 10 by unwinding the string 14 from a reel, or the like, provided on the rig 16.

[0010] A string of production tubing 20, having a diameter greater than that of the tool 12, is installed in the wellbore 10 in a conventional manner and extends from the ground surface to a predetermined depth in the wellbore 10.

[0011] As better shown in Fig. 2, three annular, axially-spaced, gravel pack support and screening devices 24a, 24b, and 24c are mounted, in any conventional manner, to the wall of the wellbore 10 adjacent the formation F. The devices 24a, 24b, and 24c can be in the form of screens, slotted liners, or any similar type of gravel support device. Although not shown in the drawing due to scale limitations, it is understood that the

devices 24a, 24b, and 24c receive one or more gravel packs, or the like, (not shown). The purpose of each device 24a, 24b, and 24c is to improve the integrity of the wall of the wellbore 10, yet allow the fluids recovered from the formation F to pass to and through the devices 24a, 24b, and 24c and into the wellbore 10, while preventing the passage of fines or sand from the fluids. Since the devices 24a, 24b, and 24c are conventional, they will not be described in any further detail.

[0012] The tool 12 is in the form of a mandrel, or cylindrical body member 30 having several components to be described mounted to it in a conventional manner. A conventional, quick release connector 30a is mounted on the upper end of the body member 30 for connecting to the corresponding end of the string 14 in a manner to permit release of the connection remotely from the rig 16.

[0013] An annular flange 30b extends radially outwardly from the upper end portion of the body member 30 and, in the operative position of the tool 12 shown in Fig. 2, engages a landing nipple 32 mounted to the wall of the wellbore 10 in any conventional manner to support the tool 12 in the position shown.

[0014] A driver, or power module 34 is mounted to the tool 12 and either contains a battery pack that provides a source of DC power, or is connected to an electrical conductor for receiving DC power from the rig 16. The power module 34 is adapted to supply electrical power for reasons to be described.

[0015] An acoustic transducer 36 is mounted on the outside of the body member 30 and is in the form of an electromechanical transducer that vibrates when it is driven, or excited by electrical power from the power module 34. The acoustic transducer 36 can be in the form of a conventional electromechanical transducer, or converter, such as a loudspeaker, tuning fork, cantilever, oval-mode tool, magnetostrictive driver, or piezoelectric transducer.

[0016] The frequency, or frequencies, of the output of the power module 34 is matched to the frequencies of the acoustic transducer 36, so that the acoustic transducer 36 is driven at its resonating frequency. For example, if the desired frequency is above 4kHz, the acoustic transducer 36 can be in the form of a piezoelectric transducer, such as those marketed under the designation PZT-4 by the Edo Corporation of Salt Lake City, Utah.

[0017] In addition to the application of the resonating frequency, the tool 12 may be coupled with a lower frequency producing device to create the localized pressure drop necessary to dislodge some of the particles.

[0018] A sensor 38 is mounted on the tool 12 and is adapted to remotely sense the accumulation of scale on the devices 24a, 24b, and 24c and output a corresponding signal. To this end, the sensor 38 can operate in several conventional manners. For example, it can transmit an audio signal in a direction towards the devices 24a, 24b, and/or 24c, measure the reflective signal returning from the devices 24a, 24b, and/or 24c, compare the difference between the signals, and output a signal based on the comparison which will correspond to the scale accumulation on the devices 24a, 24b, and/or 24c.

[0019] A control unit 40, which can be in the form of a microprocessor, or the like, is mounted to the tool 12 and although not shown in the drawing in the interest of clarity, is electrically connected to the sensor 38 for receiving the above output signals from the sensor 38 corresponding to the scale accumulation on the devices 24a, 24b, and/or 24c. The control unit 40 is also electrically connected to the power module 34 and is adapted to activate the power module 34 so that it provides the electrical power to vibrate the acoustic transducer 36.

[0020] In operation, and assuming that production fluids are recovered from the formation F, the fluids pass through the devices 24a, 24b, and 24c and upwardly in the wellbore 10 to the production tubing 20 for passing to the rig 16 for collection, while the devices 24a, 24b, and 24c prevent fines or sand from the fluids from passing with the fluids. The tool 12 is lowered into the wellbore 10 before, after, or at any stage during, the above recovery process, until the flange 30b engages the nipple 32 to locate the tool 12 adjacent the formation F.

[0021] The sensor 38 is activated to sense any accumulation of scale on the devices 24a, 24b, and 24c in the manner discussed above, and outputs a corresponding signal to the control unit 40. The control unit 40 activates the acoustic transducer 36 when the scale accumulation exceeds a predetermined threshold, and the acoustic transducer 36 functions in the manner discussed above to vibrate continuously, or at a pulsed rate, to an extent that a sympathetic vibration is imparted to the devices 24a, 24b, and 24c

which loosen the scale and cause it to fall off the devices. The removed scale can be allowed to fall to the bottom of the wellbore 10, or it could be circulated, in any conventional manner, to the rig 16 for recovery.

[0022] The vibration of the acoustic transducer 36 also stimulates the formation F adjacent the devices 24a, 24b, and 24c to promote recovery of the production fluids, and reduces the "skin" around the wellbore 10 that can slow the flow of production fluid from the formation F to the wellbore 10.

[0023] After the above operations, the tool 12 can remain in the wellbore 10 adjacent the formation F for later use, or can be removed as needed by lowering the string 14 into the wellbore 10, reconnecting the string 14 to the connector 30a on the body member 30, and then raising the tool 12 out of the wellbore 10. As a result of all of the foregoing, the scale accumulating on the devices 24a, 24b, and 24c is broken up without causing any physical or chemical damage to the devices 24a, 24b, and 24c, while the formation F is stimulated and the skin around the wellbore 10 is reduced.

[0024] The above technique is also applicable when the well is completed open-hole, i.e., with no screens, liners, etc. In this case, scale will accumulate on the wall of the well defining the bore, and can be removed in accordance with the foregoing, i.e. by vibrating the acoustic transducer 36 continuously or at a pulsed rate when the scale accumulation exceeds a predetermined threshold, to loosen the scale and cause it to fall off the wall. In this situation, it is possible to directly measure the amount of scale on the wall by directly measuring the thickness of the radius of the wellbore 10. This is achieved by using the reflected sonic signal to measure the distance to the wall of the well. This can be done during the operation of the acoustic transducer 36, in which case the thickness of the scale should initially decline quickly and is monitored as a function of time. A stabilized thickness (small change in the radius of the wellbore 10) is an indication that scale removal is complete.

[0025] In another mode, both down-hole pressure and rate are monitored. By continuously analyzing the rate and pressure, the cumulative skin factor of the wellbore 10 is calculated. Skin factor is plotted versus treating time and will initially drop quickly as the devices 24a, 24b, and 24c and the formation F are treated as described above.

The skin factor will eventually level off indicating that the optimum cleaning has taken place.

[0026] Several variations may be made in the above embodiments without departing from the scope of the invention. For example, the number of screening devices can be varied, and one or more additional power modules, acoustic transducers, sensors, and/or control units can be added to the tool 12. Also, the tool 12 can be lowered into the wellbore 10 at any stage relative to the recovery of the fluids from the formation F and can remain connected to the string 14 during the above operation. Further, the specific type of acoustic transducer 36, as well as the power module 34 to drive same, can be varied. Still further, the control unit 40 can be programmed to adjust the amount of scale accumulation that is necessary for it to actuate the power module 34. Moreover, the specific location of the above components can be varied.

[0027] The foregoing descriptions of specific embodiments of the present invention have been presented for purposes of illustration and description. They are not intended to be exhaustive or to limit the invention to the precise forms disclosed, and obviously many modifications and variations are possible in light of the above teaching. The embodiments were chosen and described in order to best explain the principles of the invention and its practical application, to thereby enable others skilled in the art to best utilize the invention and various embodiments with various modifications as are suited to the particular use contemplated. It is intended that the scope of the invention be defined by the claims appended hereto and their equivalents.

[0028] What is claimed is: